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ABSTRACT

The manual provides information on teaching techniques and services, materials, equipment, and publications for teaching chemistry to physically handicapped students. Section I addresses the classroom in terms of common needs, lecture/discussion techniques, and special arrangements. Section II covers the laboratory with general guidelines and guidelines for serving students with impaired mobility, impaired vision, and impaired hearing. Additional sections discuss laboratory safety and testing and evaluation. Also provided are a list of information sources and a bibliography. (SB)

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Teaching Chemistry

to

Physically Handicapped Students

Kenneth M. Reese, Editor

American Chemical Society
May 1981

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Foreword

Increasing numbers of handicapped students may wish to become chemists, and many need to study chemistry to attain other career objectives. The American Chemical Society, therefore, supported by the National Science Foundation, developed this manual to familiarize teachers with the practical aspects of teaching chemistry — in both classroom and laboratory—to students with physical handicaps.

The concept of such a manual evolved from a June 1978 conference on "Barriers to Postsecondary Science Education for Handicapped Students" organized by the American Association for the Advancement of Science and sponsored by the National Science Foundation. In accord with recommendations from that conference, the ACS held a workshop on the subject in April 1980. The participants (see page 42) included 15 handicapped chemists or students and seven nonhandicapped chemical educators. The workshop produced the substance of this manual, and the participants contributed additionally by reviewing preliminary drafts.

The Society will distribute the manual to chemistry faculties at some 2000 colleges and universities in the United States where chemistry is taught and also will supply copies on request. While the manual is oriented primarily toward teachers of chemistry, we hope that it will prove useful as well to students and others involved in the educational process.

James J. Hazdra
Workshop Chairman

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Introduction

The basic requirements for teaching chemistry to students with physical handicaps are capable teachers and motivated students. However, awareness of useful refinements in teaching technique and of services, materials, equipment, and publications in the field may also prove valuable. This manual is designed to provide such information for both students and teachers, but is oriented primarily toward teachers of chemistry.

Many scientists and technicians with slight to severe physical handicaps are pursuing careers in science today in industry, education, and government (42). Nevertheless, young people with handicaps traditionally have not enjoyed full access to the kind of education that would permit them to follow careers of their choice. In part the problem has been simply the physical arrangement of school buildings and facilities. But the main difficulty has been a set of deep-seated and pervasive attitudes toward handicapped people in general and the consequent barriers to young people aspiring to study science (40). Handicapped children often have not been considered in the context of standard curricula, and there is good evidence that most handicapped students until recently have not even been exposed to the sciences, including chemistry.

To help correct this situation, Congress passed the Rehabilitation Act of 1973 and the Education for All Handicapped Children Act of 1975. These measures were designed in part to make the full range of educational opportunities accessible to the handicapped.

Section 504 of the Rehabilitation Act provides that

> No otherwise qualified handicapped individual . . . shall, solely by reason of his handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance.

All schools receiving federal funds are covered by this provision. The act also provides for the removal of physical barriers to handicapped people in schools and other facilities receiving federal funds.

The Education for All Handicapped Children Act provides for federal assistance to states for educational services for handicapped individuals between ages 3 and 21. The intent is to guarantee full access to educational opportunity for all handicapped students.

The number of students covered by these laws is uncertain. The data are fragmentary and cover a wide range of impairments; furthermore, there are doubtless handicapped students who do not consider or report themselves to be handicapped and so do not appear in the data. In any event, teachers of chemistry through the university level can expect to be teaching more students with handicaps than they have in the past. The largest numbers will be in high school and in college courses for nonchemistry majors, but an increase in the numbers of handicapped students seeking associate's, bachelor's and advanced degrees in chemistry can also be anticipated.

The discussion that follows is organized in terms of the classroom, the laboratory, and testing and evaluation. The discussion is not intended to be comprehensive, but to serve rather as a briefing for teachers whose classes will include handicapped students. However, access to a broad range of information and assistance is provided by the section Sources of Information. Similarly, more than 50 pertinent publications are listed in the Bibliography, and a few of them are cited by number in the text.

In the Classroom

From the teacher's point of view, handicapped students have three kinds of classroom needs: those common among students in general; those that call for care in lecturing and leading discussions; and those that require special arrangements. Teachers as a rule can meet the first two categories of needs simply by following practices generally recognized to contribute to good teaching. The third category of needs —special arrangements—requires that teachers display flexibility and leadership; the handicapped students bear most of the everyday responsibility for making teachers aware of their special needs and for assisting in finding potential solutions.

Classroom accommodations for handicapped students tend to be highly individualized. Usually the students themselves are excellent sources of information on their needs because they have learned what works best for them. It is the student's responsibility, therefore, to initiate with the teacher a frank discussion of how to meet special needs in the most practical way. Such discussion is best held before the semester begins to allow time for teacher and student to learn each other's requirements and make the necessary arrangements.

Some handicapped students may hesitate to initiate a presemester discussion with the teacher. Here, the teacher can help by being alert to the needs of students and initiating a discussion when it seems called for. Other teachers and counselors can help by letting the teacher know of students with special needs who will be entering the class. Also, handicapped students might be encouraged to preregister so that the information can be given to the department chairman or other responsible individual in timely fashion. To repeat, it is essential that adequate time be allowed for planning before the semester begins.

It is important that the handicapped student be personally involved in discussions of special arrangements. Teachers uncertain of what to do might bypass the student and consult other teachers or advisers. The result of such a procedure is explained by a handicapped person who earned a doctorate and is now a practicing research chemist: "I was constantly frustrated in my attempts to arrange presemester conferences by teachers who said that they had 'already spoken to so-and-so and everything was arranged.' This left me completely in

the dark about what had been arranged and unable to express my views on what needed to be arranged."

Common Needs

Teachers tend to have different classroom styles, and students have different styles as well. When styles mesh poorly, the student's work may suffer. The teacher normally takes the lead in correcting matters, and this principle applies to the handicapped student as much as to any other.

Any class may include students too shy to speak up or ask questions easily; shyness in the handicapped may be compounded for various reasons. With deaf students, for example, hesitancy to speak up may be related to prior ridicule of the way their voices sound or fear that they will be unable to understand the teacher's reply. The teacher can help by involving the student at appropriate times. In any event, it is good teaching technique to encourage all students to participate actively in class. The practice benefits students and helps teachers monitor their progress.

Many students like to review subject matter before it is taught in lecture or recitation sessions. Thus it is helpful to make syllabi and other course materials accessible to all students as far in advance as possible; it is especially helpful to handicapped students who may prefer to rely particularly on advance preparation and organization. In the same vein, timely explanation of course requirements and objectives is extremely helpful to handicapped and able-bodied students alike.

Lecture/Discussion Techniques

Teachers who are careful about their techniques in lecturing and leading discussions are likely to be helping all of their students, but good technique is particularly valuable to handicapped students. The governing principle is to speak and gesture as clearly and specifically as possible. Beyond that, the utility of various elements of good technique depends on whether the student is totally blind or deaf or has partial sight or hearing. Orthopedic handicaps usually do not require special awareness of classroom communication techniques.

It is natural to call on students by pointing, but the blind student obviously must be referred to by name as well. The practice is sound for any student. Similarly, the teacher can help students with impaired vision by referring to material on the blackboard by name. For example, one would say "benzene," not "this compound;" one would say "from 20 degrees Celsius to 40 degrees Celsius," not "from this temperature to that." Blind students have their own ways of learning

from graphics—the use of raised-line drawings* is one such method. Still, the student can learn from graphics presented in class if the material is described carefully. Such material is best described in consistent fashion — for example, clockwise or left to right. Blind students may also find it useful to have access to molecular models of structures discussed in lectures.

Students who are deaf or have impaired hearing need to be called on by first ensuring that there is appropriate eye contact. Speaking the student's name at the same time can help the teacher keep other students involved. Teachers can help also by remembering to keep their faces fully visible to the class when speaking. The deaf student who is speechreading (lipreading) or watching an oral or sign-language interpreter cannot take notes properly, read written material, or watch a demonstration.

Without an interpreter, neither deaf nor hard-of-hearing students can follow what other students are saying if remarks come from the back of the classroom. The teacher can help in several ways: by passing out printed material before class; by inserting appropriate pauses during demonstrations; by repeating questions asked by other students; and by summarizing classroom discussion on the blackboard at logical points. These practices can be useful to all

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*The following is a simple do-it-yourself technique for making raised-line drawings. This cheap, quick, and efficient method can be used by a lab assistant or anyone who is interested to clarify lecture material or diagrams for blind students.

Materials needed:

— tabletop or hard, flat surface
— thin sheet of rubber, leather, Naugahyde, or any pliable surface
— thick paper
— tracing wheel

Lay a thin sheet of pliable material on a hard, flat surface. On top of this, place a piece of thick paper. Sketch in ink or in pencil the *mirror image* of the desired drawing onto the paper, or photocopy the diagram onto thin, translucent paper and turn over before placing on the rubber surface. Firmly trace over the lines with a tracing wheel. Turn the paper over and you will have a raised-line drawing.

students. Because many scientific terms do not have signs,* deaf students can benefit from seeing new terminology on the blackboard or on overhead transparencies. In discussion sessions, the teacher can help to keep the deaf student abreast by controlling the pace of the discussion. Allowing only one student to speak at a time, again, can benefit the entire group. See Figure 1.

While the foregoing accommodations may sound complicated to a teacher who has never considered them before, they are, in fact, not difficult procedures.

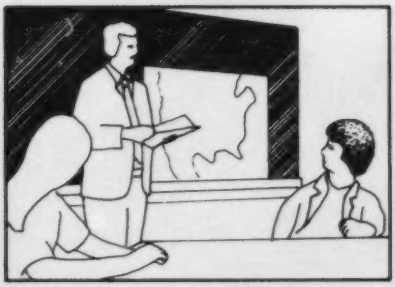
Special Arrangements

Special classroom arrangements for handicapped students can be worked out by teacher and student; as noted earlier, such arrangements are best made before the semester begins. Seating plans, for example, are important to students with hearing, visual, and orthopedic handicaps. Some students may need notetakers or classmates who are willing to share their notes; they may wish to have photocopies or carbon copies of sets of notes taken by several students to compensate for individual habits in notetaking. Other students may need oral or sign-language interpreters or may ask permission to tape lectures.

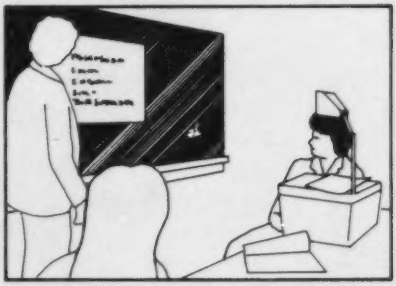
In meeting these special classroom needs, it is the handicapped student's responsibility to arrange for some of the required services; the situation varies from state to state. Such services might include the transcription of tapes for deaf students or the conversion of printed course materials into braille, large print, or tape and the conversion of diagrams and graphics into raised-line form for blind or visually-impaired students. (Recordings for the Blind converts printed text materials free, and loans the recordings to blind persons. See p. 32.) Many schools have an office that provides and coordinates such services for handicapped students, and many state vocational rehabilitation agencies usually pay for support services. Teachers can help in several ways. They can help find volunteers to take or share notes. They might agree to make their own notes available to the class as a whole or offer to allow their lectures to be taped subject to an agreement that the tapes are for personal use only. And in general, teachers can take the lead in creating an accommodating and receptive atmosphere in the classroom. In this vein, teaching assis-

*The Technical Sign Project Staff at the National Technical Institute for the Deaf is currently collecting, evaluating, and recording signs for scientific terms, including chemistry. See Sources of information, p. 28.

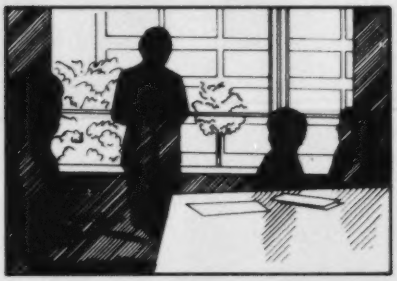
Figure 1. Group Communication Techniques



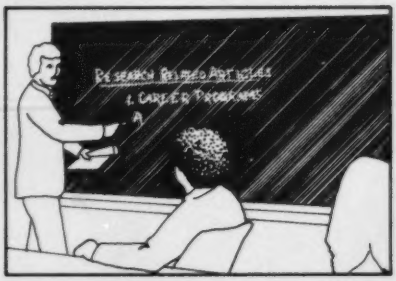
The deaf person should sit near the speaker.



Use visual aids to supplement a presentation.



Avoid standing in front of a light source.



Face the deaf person. Do not speak while writing on the chalkboard.

Provide new technical vocabulary in advance.

Make a special effort to clarify vital information.

(Based on material provided by, and used with permission of, the National Technical Institute for the Deaf)

tants, where available, can be helpful, in part because handicapped students may consider them more approachable than the teacher.

Another source of assistance with both special and general needs is the chemical fraternity Alpha Chi Sigma, which has developed a service program for handicapped students of chemistry. If there is a chapter on campus, its members can be called on for advice and for help of particular kinds, such as reading to blind students, converting diagrams and graphics into raised-line drawings, or administering examinations. (See Sources of Information, p. 25).

In the Laboratory

Laboratory experience is essential for students of an experimental science like chemistry, and the handicapped student is no exception. Some handicapping conditions clearly will restrict the student's laboratory activities more than others, and the level of involvement desirable and necessary must be determined on an individual basis. Students whose efforts in the laboratory are sharply restricted by a handicap are not necessarily barred from careers involving laboratory work. Many successful chemists direct experimental programs without the need to perform laboratory manipulations themselves. Often they work with data obtained using methods outside their immediate experience and equipment they may never have seen. It should be noted also that many handicapped chemists work in the lab in the same manner as able-bodied scientists, with few or no special accommodations.

General Considerations

Certain general considerations apply to all handicapped students entering a laboratory course. It is important, for example, to involve the laboratory assistant from the beginning. The teacher can do this by scheduling a conference with the assistant and the student before lab work begins and by seeing to it thereafter that the two remain in regular contact. Not all schools or departments have teaching assistants, so their role in accommodating the handicapped student has to be assumed by the teacher or perhaps by a well-qualified student. It is customary in some lab courses to pair students as partners. In this case, it is important to help the handicapped student locate a congenial lab partner or group and to check occasionally to be sure everything is well.

If a student needs extra time to complete a lab assignment, the teacher should try to be flexible. Extra time might be available in a Saturday section, or a student might enter an additional lab section during the week or start early or stay late in the regular section. Scheduling extra time may be more difficult in small schools or departments with relatively few lab sections. In any event, it is best that student and teacher agree on the amount of extra time that is

reasonable so that time does not become an issue when the student's work is evaluated.

Some physical modifications in the lab might be necessary. They are discussed briefly below in terms of specific categories of handicaps. For access to more detailed information, see Sources of Information. Again, whatever modifications are desired may require ingenuity on the part of the small school or department with limited financial resources (43).

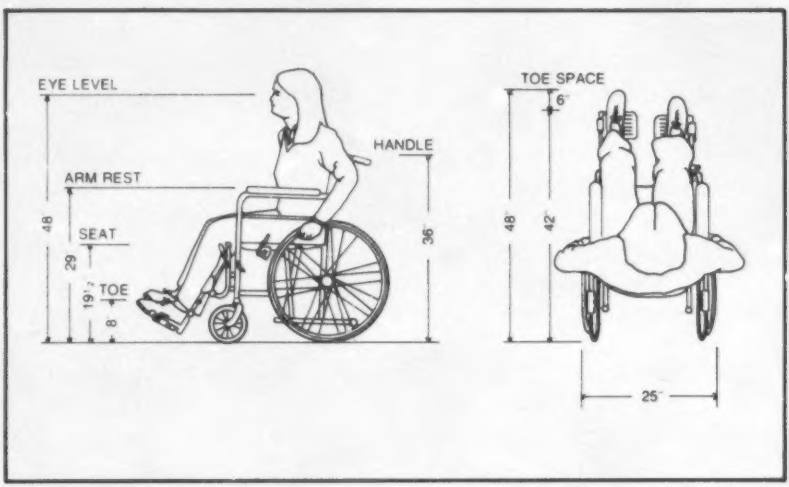
Impaired Mobility

The student with impaired mobility needs to have easy access to equipment, materials, safety devices and other services, and exits. The student also needs enough aisle space to permit lateral movement and maneuverability. Positioning a wheelchair parallel to the lab bench is generally restrictive, although some students might prefer it.

The basic requirements for a laboratory work station for a student in a wheelchair have been described (15). See Figure 2. Briefly, they are

- Work surface 30 inches from floor
- 29-inch clearance beneath the top to a depth of at least 20

Figure 2. Standard Wheelchair Dimensions



(Based on material from, and used with permission of, the Association of Physical Plant Administrators of Universities and Colleges)

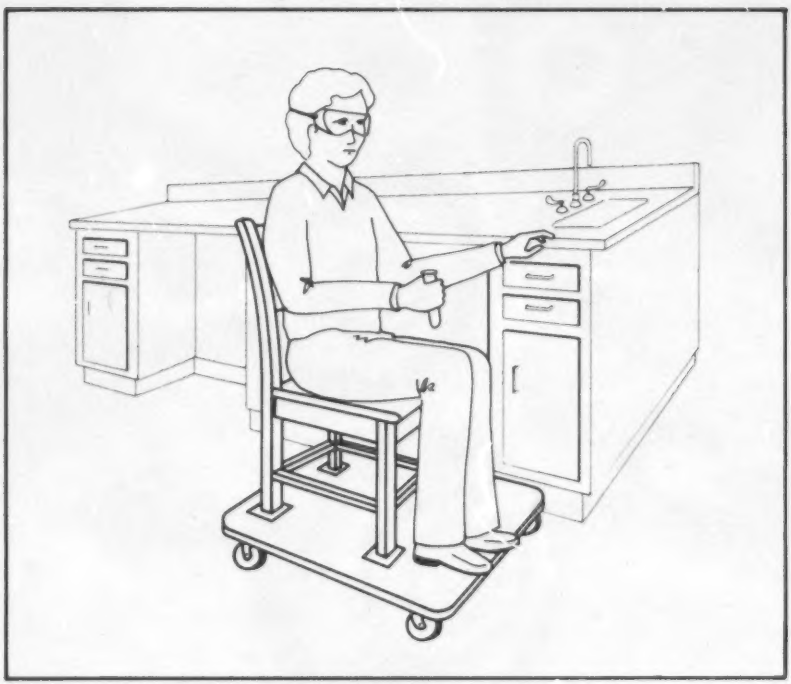
inches and a minimum width of 36 inches to allow leg space for the seated individual

- Utility and equipment controls in easy reach
- Clear aisle width sufficient to maneuver a wheelchair— recommended aisle width is 42 to 48 inches.

Should the aisles be too narrow, a lab station can be set up at the end of the bench or a portable station can be designed or purchased and positioned as desired (such as the Conco portable lab station, see Appendix p. 31). Another alternative, if the student can transfer from the wheelchair, is to design a more maneuverable chair for use in the lab only. Two such designs that have worked well are

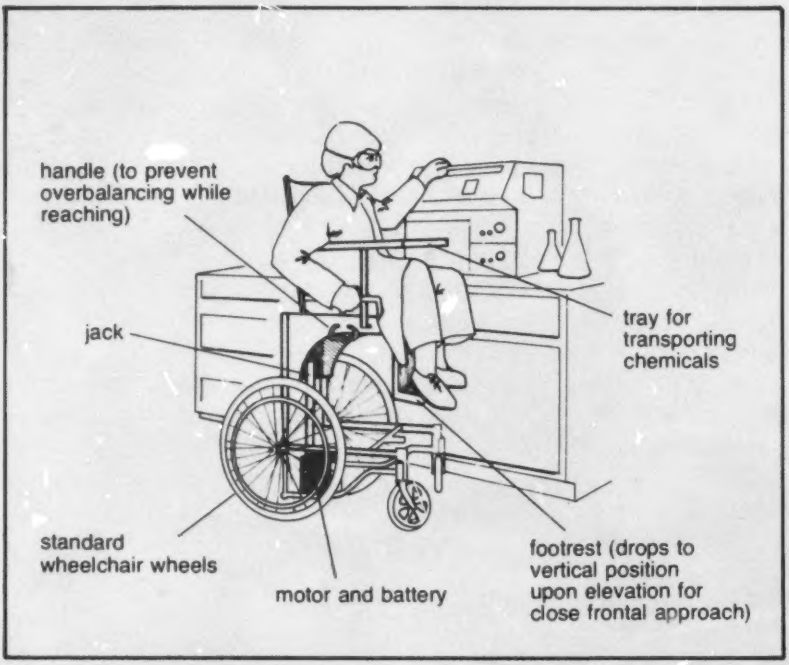
- An ordinary armless chair secured to a platform that moves on casters. To move, the rider pushes against the floor with rubber-tipped canes (15). See Figure 3.
- An adjustable-height wheelchair made from an old office chair, a set of wheelchair wheels, and a hydraulic truck jack with a 6-inch lift (43). See Figure 4.

Figure 3. Platform Chair



(Based on material from, and used with permission of, the Association of Physical Plant Administrators of Universities and Colleges)

Figure 4. Adjustable Height Wheelchair


handle (to prevent overbalancing while reaching)
jack
tray for transporting chemicals
standard wheelchair wheels
motor and battery
footrest (drops to vertical position upon elevation for close frontal approach)

(Based on photograph provided by Brock University, St. Catharines, Ontario, Canada)

Compared to a wheelchair, these homemade designs permit good mobility around the lab, increased mobility at the bench, and increased accessibility to the bench top. Supplies and equipment can be moved around the lab on the chair-and-platform device, which provides a flat, steady surface. The adjustable-height wheelchair may include a tray that can be snapped onto the chair's arms to carry equipment such as flasks and crucibles, leaving both hands free to operate the chair. Mobility and accessibility at the bench can also be enhanced by constructing a platform to raise the student to a height more compatible with the height of the bench top and by modifications to the bench itself, such as pull-out shelves.

One graduate student in chemistry who uses a wheelchair performs most experiments on a standard vacuum rack. This 22-inch high, 12-inch deep workspace provides the vertical access required by a seated individual for doing titrations, distillations, and column chromatography (28).

The laboratory as a whole can be made more accessible to students with impaired mobility by making various modifications:

- Adjustable-height storage units and special-equipment work spaces
- Pull-out or drop-leaf shelves or counter tops for auxiliary use—for example, shelves at lap-board height for holding instruments to be used by students in wheelchairs
- Single-action lever controls or blade-type handles rather than knobs for students with impaired manual dexterity
- Flexible connections to electrical, water, and gas lines for students with limited reach (i.e., in a wheelchair)
- Alternate means of storage, such as a portable lazy susan or a storage cabinet on casters

Students whose handicaps affect the use of both upper and lower limbs will need a full-time assistant to perform experiments under the student's direction; the student should be able to observe the data acquisition as well as direct the experiment. This approach for the quadriplegic student is much the same as that described for the blind student in the following section.

The foregoing provisions for making a laboratory more accessible to students with impaired mobility have been used successfully by various disabled scientists. Again, however, students' needs tend to be highly individualized, so accommodations are best considered on a student-by-student basis.

Impaired Vision

Many students with severe visual handicaps have mastered chemical-laboratory work. Blind students who have been accommodated in the laboratory testify that the work is not only educational, but enjoyable; for them, the hands-on experience was vital. Some students with impaired vision have completed laboratory sessions virtually unnoticed, possibly using only a magnifying glass or relying informally on a partner or nearby classmate to read numbers or confirm observations. Other students with impaired vision require more help. The degree of disability determines the policy to be adopted.

The blind student often will require a full-time laboratory assistant. The assistant should not be taking the course, but it is useful to have one who has done so and knows the equipment and terminology. The blind student does the thinking and directs the assistant to give visual feedback on command. It is helpful for the student to be given

the opportunity before the lab session to feel an appropriate configuration of the experimental apparatus. This allows the student to visualize how the equipment should be assembled. It is important that the student be encouraged to exercise as much independence as possible. In some cases, however, it may be necessary for the assistant to manipulate the equipment. Selecting the laboratory assistant is the joint responsibility of the blind student and the instructor (the latter can be held legally responsible for mishaps in the laboratory, however, and so should have veto power over the selection). The instructor can help by suggesting names. The instructor also should see that the assistant functions properly. When questions arise, for example, the student should take them up directly with the instructor, not through the assistant, and vice versa.

Blind students negotiate best in familiar surroundings. Even though they may never need to visit remote parts of the laboratory they should be allowed to familiarize themselves with the entire setting. A short time with the lab instructor locating sinks, reagent shelves, hoods, safety showers, and the like, will orient the student and help to determine the best place to work. The student will find the exits, learn the bench configurations, memorize the positions of the utilities, and so forth. The laboratory becomes familiar and comfortable. This orientation session can also be used to explain the safety rules and outline fire-drill and other procedures. It is also the time to explain what locations in the laboratory pose the greatest potential hazards.

Blind students who have guide dogs may decide not to take them into the laboratory. A small office nearby or an out-of-the way spot at the far end of the balance room might be an ideal place to leave a dog. Guide dogs are obedient and accustomed to waiting.

Students with partially impaired vision may require no special laboratory assistance at all. Yet, one lab station may be better than another because the lighting is better, for example. Some students with partial sight may need larger letters on reagent bottles, a magnifying glass to read burettes, or a larger notebook than prescribed for the course. Such requirements are easily met; usually the student takes care of them.

The development of special equipment to facilitate laboratory work for students with impaired vision is a relatively new area of research, but progress is being made rapidly. References to such equipment can be found under Teaching/Laboratory Aids in Sources of Information. Examples of equipment now available include:

- Voltmeters with audible readout
- Liquid-level indicator
- Electronic calculator with braille printout
- X/Y plotters with braille output
- Talking thermometers
- Talking calculator
- Light probe (used as part of readout devices—it emits a tone which increases in pitch proportionally to changes in light intensity)
- Braille labeler
- Braille and talking computer terminals

Impaired Hearing

Unlike visual and orthopedic disabilities, impaired hearing is not a visible handicap unless one sees the student wearing a hearing aid or using sign language. However, since hearing is required for control of voice quality, deaf people may speak with inappropriate pitch, volume, or articulation. Also, deaf people may sometimes have to be told that they are making noise which is disturbing people who can hear. But in general, impaired hearing has little effect on the ability to work in a chemical laboratory. Excepting the installation of visual warnings in addition to normal audible warnings, and emphasis on good communications, students who are deaf or hearing-impaired have few special needs in a chemistry laboratory.

Deaf students also face a social barrier in that deafness impedes communication with other students. The teacher can be helpful by assisting in finding a sensitive lab partner when a partner is needed.

Laboratory Safety

Safety in the chemical laboratory has received a great deal of attention over the years and has been the subject of numerous publications (12,13, 41). Safety measures for handicapped students are not usually considered in such documents, but logically should be based on the precautions established for all students. From this perspective, the extra measures entailed by the presence of handicapped students comprise a small increment in the body of general safety requirements and practices.

There is no reason to assume that handicapped students will be less careful or will pose a greater hazard than other students in the laboratory. This argument was borne out by a study of 1400 handicapped employees at Du Pont (47). The author commented, "Du Pont's experience has proven that disabled workers are safe workers."

Federal standards for occupational safety in laboratories are the province of the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor. Consequently, a participant in the workshop that developed the substance of this manual asked OSHA for its position on physically handicapped students and laboratory safety, and Dr. Eula Bingham, Assistant Secretary of Labor for OSHA, responded:

> As you are aware, the Occupational Safety and Health Act of 1970 addresses protection of workers, not students. For this reason OSHA regulations do not impact upon the placement of handicapped students in laboratory or other courses. The Department of Health and Human Services is responsible for administering regulations mandating accessibility of courses to handicapped students.
>
> While OSHA's responsibility and authority is limited to employees rather than students, OSHA recognizes the needs and rights of physically handicapped students to equal opportunity in education including laboratory sciences. If questions concerning compliance with OSHA standards arise, employers, handicapped individuals, and other interested persons may request information and assistance by contacting the nearest OSHA office. In addition, OSHA's on-site consultation program provides visits to worksites, advice and technical assistance at the request of employers on OSHA related problems, including

any that might involve handicapped employees. The handicapped are very important and productive members of America's workforce, and we fully concur with you that they should have an equal opportunity for placement in suitable jobs. In developing future workplace standards, we intend to exert care to assure no prejudicial effects to the handicapped.

Safety professionals are one possible source of up-to-date information on chemical and laboratory safety. The school that does not have a safety professional might obtain help from one at another school or a nearby laboratory. Such individuals should be knowledgeable about regulations and practices and be able to define the "reasonable precautions" required of the teacher in particular circumstances. Not all safety professionals, however, can be expected to be knowledgeable about good safety practices for handicapped students or scientists, and it can be helpful to clarify this point with them. Information on chemical safety can be obtained from the ACS Chemical Health and Safety Referral Service, which is designed to steer callers toward the proper resources. See Sources of Information, p. 25.

There is certainly a need to enforce good laboratory practices and sensible safety measures for students. The suggestions that follow apply to all students; those that are oriented particularly toward handicapped students are indicated by asterisks. This is not an attempt to provide a comprehensive discussion on lab safety; more complete consideration of general laboratory safety practices can be found in the ACS safety manual (12).

1. Always discuss procedures and any special safety considerations with the students before allowing an experiment to begin.

2. Arrange and discuss evacuation plans for fire and other emergencies. Review such plans periodically.

3. Give all students safety quizzes or safety-rule sheets to read, sign, date, and return to the instructor. Go over these procedures and rules with the students. Use open-ended questions to obtain clarification.

4. Post copies of the safety rules at several locations in the lab and give a copy to each student.

*5. Give the student with impaired vision an opportunity to become familiar with the laboratory before the first session. The student can then participate in the safety-orientation program with

little trouble and will already know the locations of exits, showers, and extinguishers.

*6. Discuss and resolve individual limitations with the student with impaired vision who has no full-time lab assistant. Can the student read labels? Are the labels big enough? Consult with the student as to whether there are any operations too risky for the student to handle alone.

7. Do not use the shower area for temporary storage.

8. Keep all aisles free of obstructions.

9. Ensure that reagent containers are labeled clearly and returned to their shelves after each use. These shelves should be readily accessible to the handicapped student.

*10. Assign the student with impaired mobility to a lab station on an outside aisle and close to an accessible exit, if possible. Students with impaired hearing should have lab stations that afford an unobstructed view of the instructor.

11. Insist on the use of eye-protection devices such as goggles or safety glasses with clear side shields at all times in the lab.

12. No students should pour from large containers of concentrated acids or bases. Reagent containers too large to be easily grasped by one hand have no place in any instructional chemistry laboratory.

*13. Students, including those with impaired vision or poor manual coordination, are strongly urged to wear rubber gloves when working with harsh chemicals or those readily absorbed by the skin. Disposable, lightweight gloves are available which will permit the student to manipulate equipment.

*14. All students should wear plastic or rubber aprons when working with chemicals in order to protect their clothing. Students in wheelchairs or those who have no sensory perception in the lower half of the body should be advised of the importance of protecting their laps with a heavy rubber apron while working with chemicals.

15. Employ the buddy system in the lab for assistance in emergencies.

16. Prohibit both able-bodied and handicapped students from working in the lab alone. Although it is a reality in some laboratories,

ACS does not advocate the practice of graduate students working alone late into the night to finish or monitor experiments.

*17. Accessible and usable eye washes should be located near the handicapped student's work station.

18. Equip laboratories with emergency lighting (using batteries or another power supply) in case of power failure. Emergency lighting is particularly needed for deaf students as they rely on visual clues more than do students who can hear.

*19. When a deaf student is working in a lab, it is helpful to have available equipment with lights or other visual means of indicating on/off status, although most equipment can be monitored easily by touch. Alarm systems also should be visual, with flashing lights. Expensive changes to equipment are seldom needed for deaf students, however. For example, they can feel when a timer sounds if they hold it in their hands.

20. Ensure that combustible gas supplies from the gas jets on the benches contain odorants. Students with impaired hearing may not hear the sound of an open gas jet, although they will be more inclined to check visually than will students who can hear.

*21. Lightweight fire extinguishers should be provided for mobility-impaired students, but all students should be instructed in the use and limitations of fire extinguishers and in fire drill procedures. Lightweight dry chemical fire extinguishers are often the only kind a mobility-impaired student can handle. Almost all dry chemical fire extinguishers have a greater effective range and extinguishing capacity than the carbon dioxide extinguishers usually provided in laboratories. For example, a fully charged 5 lb. carbon dioxide fire extinguisher, the minimum required size, weighs 14 lbs. and has a 5B rating. It is good for a fire of approximately 5 square feet of burning liquid. On the other hand, a 5 lb. dry chemical fire extinguisher can weigh as little as 8½ lbs.—it has an aluminum rather than a steel shell—and carries a 40B rating. This means it is eight times more effective than a 5 lb. carbon dioxide extinguisher. Also, if a dry chemical fire extinguisher weighing 8½ lbs. has both an A and a B rating, it is also equal to 2½ gallons of water, which gives it the same extinguishing ability as an ordinary 2½ gallon water extinguisher weighing 27 lbs.

Testing and Evaluation

Administration of tests to handicapped students may require a degree of accommodation by the teacher. Experienced students who cannot take written examinations in the usual manner will have worked out an effective alternative. The inexperienced student may need to settle on a mutually satisfactory method with the teacher. (The "Handbook for Blind College Students" is very helpful for inexperienced students (21)). Arranging for special equipment or assistance, again, is the student's responsibility.

Special conditions may make it necessary to test handicapped students orally or with the assistance of a reader/writer. However, handicapped and able-bodied students often can take tests at the same time and place by using measures that include:

- Putting tests and/or answers on tape or in braille
- Use of a facial mask to shield the sound of putting answers on tape
- Use of talking calculators with an earplug
- Use of the Optacon (optical to tactile converter—scans written material
- Use of typewriters or writing guide

Various contingencies must be planned for. Some visually handicapped students, for example, may need paper of nonstandard size for tests. Local societies for the blind often will convert tests into braille, but may take one or two weeks to do so. Also, because the language of chemistry is not purely descriptive, care must be taken to see that it is converted into braille accurately and completely. Here, a graduate student or advanced undergraduate can help by checking the translation with the aid of a blind person ahead of time.

Students who became deaf before they learned to speak may sometimes have difficulty expressing themselves with proper sentence structure. This is largely due to the difficulty of learning to read and write a language they've never heard; English is like a foreign language for some deaf students. In grading tests, therefore, care must be taken to distinguish the student's grasp of the subject matter from handicap-related writing deficiencies. Deaf students may not follow all of the postexamination discussion in class; the teacher can provide helpful feedback by taking extra care with comments written on the student's examination paper.

Students who use special methods to take tests may need extra time. The amount of extra time that can reasonably be permitted must be determined by the teacher. The circumstances will vary from student to student and method to method, and teachers encountering the situation for the first time may wish to consult the student's previous teachers or colleagues with pertinent experience. The most important person to consult is the student, who is the best source of information on how he can demonstrate his knowledge of the course most effectively. This is the time when a frank discussion between teacher and student can be extremely important.

The critical need in testing and otherwise evaluating handicapped students is to ensure that their performance is measured on the same scale as the performance of other students. Special methods and time allowances, where permitted, must be handled so that the student is evaluated under circumstances that, except for the disability, are fully equivalent to those imposed on other students.

Closing Comment

The foregoing discussion and the following sections—Sources of Information and Bibliography—represent a considerable volume of material on teaching handicapped students. Of all this material, two salient points bear repetition for teachers of chemistry. One is that students, handicapped or not, tend to have highly individualized needs and learn best when taught on that basis. The other is that handicapped students, by and large, have made the extra effort to get where they are and wish to be judged against the recognized standards of academic achievement.

There is a third and overriding point—the need to recognize and so learn to correct the deep-seated attitudes that long have denied to many handicapped young people the opportunity to pursue educations and careers of their choice. Society tends to equate a physical handicap with reduced abilities overall. In fact, a handicap is but one determinant — and by no means the most important — of an individual's capacity. By recognizing that point, teachers and others involved in the educational process will enhance the utility of this manual to themselves and to the students whose futures they may influence so much.

SOURCES OF INFORMATION

ORGANIZATIONS INVOLVED IN EDUCATION OF HANDICAPPED STUDENTS

Alpha Chi Sigma Fraternity
11 South Kitley Avenue
Indianapolis, IN 46219

American Association for the Advancement of Science (AAAS)
Project on the Handicapped in Science
Office of Opportunities in Science
1776 Massachusetts Avenue, N.W.
Washington, DC 20036
Phone: (202) 467-4497
Dr. Martha Ross Redden, Project Director

AAAS is a major resource center promoting access to science for the handicapped. Publications include a free brochure, "Project on the Handicapped in Science," and two books: *Resource Directory of Handicapped Scientists* and *Science for Handicapped Students in Higher Education: Barriers, Solutions, and Recommendations*. The AAAS Chautauqua Short Course, "The Handicapped Student in Science" provides information to college science teachers who will have handicapped students in their classes. The course is sponsored by the National Science Foundation.

American Chemical Society

a) Committee on the Handicapped
1155 16th Street, N.W.
Washington, DC 20036
Phone (202) 872-4600
Dr. Thomas Kucera, Chairman

b) Chemical Health and Safety Referral Service

ACS has a Chemical Health & Safety Referral Service to assist its members and others in dealing with problems in this important and growing area of chemistry.

Although the service is not intended to be a resource for direct answers to chemical health and safety questions, it is hoped that it will guide inquirers to appropriate resources. Currently such

resources include books, periodical articles, films, educational programs known to be available, and government agencies and other organizations oriented to health and safety matters. Eventually the service may be able to provide names of qualified resource people who are willing to give advice and assistance on questions in the field of chemical health and safety.

The referral service is accessible by telephone at (202) 872-4511, and is directed by Barbara Gallagher, who heads ACS Library Services.

Assistive Device Center
School of Engineering
California State University
Sacramento, CA 95819
Phone: (916) 454-6422
Dr. Albert Cook, Director

Dr. Cook has a project to establish a data base consisting of information on assistive devices, bibliographic references, service agencies, and resource persons for disabled students in science and engineering.

Association on Handicapped Student Services Programs in Post-secondary Education (AHSSPPE)
Handicapped Student Services
Office of Student Life
206 Student Services Building
Iowa State University
Phone: (515) 294-1020
Jan Huss, President

AHSSPPE is an association of leaders in the field of providing services to handicapped students on American college campuses. Information sharing is a key element of its work.

Foundation for Science and the Handicapped (FSH)
154 Juliet Court
Clarendon Hills, IL 60514
Dr. S. Phyllis Stearner, Treasurer

FSH is an organization of handicapped scientists which functions as a resource and advocacy group promoting access to science education and employment for the handicapped. FSH publishes a newsletter.

Gallaudet College
Kendall Green
7th and Florida Avenue, N.E.
Washington, DC 20002

Gallaudet, a school for the deaf, offers *The Deaf Student in College,* a free, two-booklet portfolio which outlines how to meet the needs of deaf students on regular integrated campuses. It also describes over 60 deaf student programs currently available on campuses across the country. Write for the publication list for prices of films, books, and resource materials for teachers of deaf students.

HEATH (Higher Education and the Handicapped) Resource Center
American Association for Higher Education (AAHE)
American Council on Education
One Dupont Circle, Suite 780
Washington, DC 20036
Phone: (202) 833-4707
Rhona C. Hartman, Coordinator

The HEATH Resource Center is an information exchange about higher education and the handicapped. You are invited to make inquiries, air views, or provide input to the Center. Ms. Hartman is available to discuss your concerns on the telephone, afternoons, Eastern time.

Johnson County Community College
College Blvd. at Quivira Road
Overland Park, KS 66210

The school has developed sign language for business, data processing, electronics, and algebra.

Lawrence Hall of Science
Centennial Drive
University of California
Berkeley, CA 94720
Phone: (415) 642-3679
Dr. Herbert D. Thier, Associate Director

This organization has developed hands-on science materials for multisensory science experiences for physically disabled children, including Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH)

National Federation of the Blind
1800 Johnson Street
Baltimore, MD 21230
Phone: (301) 659-9314

A national organization of blind persons, the student division publishes *Handbook for Blind College Students* which contains advice on notetaking, testing options, procedures for making campus contacts, places where texts can be transcribed, and, in addition, where materials of any sort can be located around the country.

National Association of Students with Handicaps (NASH)
Oklahoma State University at Stillwater
1000 North Star 27
Stillwater, OK 74074
Phone: (405) 624-9366
Rusty Miller, President

NASH is a national organization of students with disabilities whose members are disabled-student organizations from universities and colleges. NASH is a national voice for these groups and provides information concerning campus accessibility and assistance in forming a local chapter.

National Science Teachers Association (NSTA)
1742 Connecticut Avenue, N.W.
Washington, DC 20009
Phone: (202) 265-4150

National Technical Institute for the Deaf (NTID)
One Lomb Memorial Drive
Rochester, NY 14623

NTID's Project Outreach serves as a resource for other educational institutions involved in teaching deaf people in regular classes. NTID conducts training programs for interpreters, notetakers, and tutors and can advise other colleges on setting up similar programs. Descriptive material is available on written request.

The Technical Sign Project Staff at NTID is collecting, evaluating, and recording signs for terms in the sciences, including chemistry. The institute teaches deaf students in an integrated setting.

The National Center on Employment of the Deaf is a national resource at NTID for career matching, employment information, and referral for hearing-impaired postsecondary people and for employers.

President's Committee on Employment of the Handicapped
1111 20th Street, N.W.
Washington, DC 20210
Phone: (202) 653-5044

Regional Rehabilitation Research Institute on Attitudinal, Legal and Leisure Barriers,
1828 L Street, N.W.
Suite 704
George Washington University
Washington, DC 20036
Phone: (202)676-6377

The institute conducts research and prepares materials for rehabilitation professionals and the general public on attitudes related to physical and mental disabilities. Publications include a series of booklets dealing with attitudinal barriers toward various disabilities; annotated bibliographies, guides to organizations, employment rights, and implementation of Section 504 of the Rehabilitation Act of 1973.

Science for the Handicapped Association (SHA)
University of Wisconsin, Eau Claire
SSS 201
Eau Claire, WI 54701
Dr. Ben Thompson, Secretary-Treasurer

SHA promotes science for all handicapped children. The Association publishes a newsletter containing bibliographic citations on science for the handicapped as well as descriptions of current research, conferences, and courses. Upon payment of dues, SHA will supply a bibliography if requested.

Wright State University
Handicapped Student Services
Dayton, OH 45435
Mr. Steve Simon, Director

The Handicapped Student Services Office has had four years' experience in adapting lab courses for orthopedically and visually handicapped students, mainly in the biological sciences.

TEACHING/LABORATORY AIDS

The following products are listed solely to provide the reader with some examples of available teaching aids. This list is not intended to be comprehensive, nor is it meant to be an endorsement of these products and producers by the American Chemical Society, but rather, is a compilation of teaching and laboratory aids known to the workshop participants.

American Foundation for the Blind
15 West 16th Street
New York, NY 10011

The foundation supplies a free catalogue as well as *International Guide to Aids and Appliances for Blind and Visually Impaired Persons* ($3.00). Some items include a talking thermometer, a talking digital multimeter, a talking micrometer, and a talking Vernier caliper.

American Printing House for the Blind, Inc.
1839 Frankfort Avenue
Louisville, KY 40206

The organization offers a light probe, talking calculator, and books in braille and enlarged print.

Automated Functions, Inc.
2800 Quebec Street, N.W.
Suite 407
Washington, D.C. 20008

The company makes and sells a talking computer terminal.

Braille Book Bank
National Braille Association, Inc.
422 Clinton Avenue, South
Rochester, NY 14620

The Book Bank supplies college texts.

Braille Technical Tables Bank
National Braille Association, Inc.
c/o Mrs. James O. Keene
31610 Evergreen Road
Birmingham, MI 48009

The association supplies thermoform copies of math and scientific tables.

Captioned Films for the Deaf Distribution Center
814 Thayer Avenue
Silver Spring, MD 20910
Phone: (301) 587-5940 (voice and TTY)

The Center produces and distributes captioned films. Educational and theatrical films are catalogued, the majority being for primary and secondary schools on nonscientific subjects. There are a few films which have a sound track synchronized with captions, some of which deal with basic chemistry concepts.

Conco Industries, Inc.
30 Water Street
West Haven, CT 06516
Phone: (203) 934-5271

The company supplies a portable lab station for students with orthopedic impairments.

Maryland Computer Services
502 Rock Spring Avenue
Bel Air, MD 21014

The company produces talking computer terminals.

National Registry of Interpreters for the Deaf
814 Thayer Avenue
Silver Spring, MD 20910
Phone: (301) 588-2406

The Registry issues 10 Regional Directories of certified interpreters. Each Directory — corresponding to each Federal Region — is available for $2.00 plus postage. The directories provide information about certification, costs, availability, training, and other useful materials. The fees for certified interpreters range from $10.00 to $18.00 per hour.

National Technical Institute for the Deaf
Rochester Institute of Technology
One Lomb Memorial Drive
Rochester, NY 14623

NTID produces a Notetaker (special tablet). It is useful for students with impaired upper extremities as well as for deaf students.

Recordings for the Blind
215 East 58th Street
New York, NY 10022
Phone toll free: (800) 221-4792

This organization will transcribe textbooks onto tape (from K to postsecondary levels) and selected diagrams and graphics into raised-line drawings. This service is free and the materials are on loan.

San Francisco Lighthouse for the Blind, Inc.
745 Buchanan Street
San Francisco, CA 94102

The organization supplies a light probe (emits a tone which increases in pitch with changes in light intensity — often part of readout devices).

Sargent Welch Corporation
9520 Midwest Avenue
Cleveland, OH 44125

Sargent Welch Corporation is a dealer handling many instruments with Binary Code Decimal (BCD) output. Some of these instruments are spectrophotometers, pH meters, Mettler balances, Ohaus balances, and electronic counters. Any instrument with a BCD output can be interfaced to the Talking Box produced by Telesensory Systems. (See below)

Science for the Blind Products
Mr. and Mrs. Tom Benham
Box 385
Wayne, PA 19087
Phone: (215) 687-3731

The company offers a catalogue as well as instruments adapted for use by the blind in science labs, such as

Aud-A-Mometer (voltmeter)
Aud-a-Val (light probe)
Aud-A-Simpson (liquid-level indicator)

Sensory Interface Systems
Larry Waldron
4442 Kasson Road
Syracuse, NY 13215

The following digital equipment can be interfaced with talking modules:

calculator
electronic balance
multimeter

Telesensory Systems, Inc.
3408 Hillview Avenue
Palo Alto, CA 94304

The company offers the Optacon, the Talking Box voice synthesizer, and the Speech Plus calculator.

Triformation Systems, Inc.
3132 S.E. Jay Street
Stuart, FL 33494

The company supplies braille computer terminals.

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This book contains a series of articles on the nature of hearing impairment and the classroom implications of deafness. It offers many practical solutions and contains a useful bibliography at the end.

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The National Science Foundation funded this project, which was organized by the American Chemical Society with Dr. Moses Passer as Project Director and Dr. James J. Hazdra, Workshop Chairman. The ACS Committee on the Handicapped, chaired by Dr. Thomas Kucera, was invited to aid in the selection of participants for the April 1980 workshop and to act as the steering group for the project.

Participants were selected from a list of handicapped chemists supplied by the AAAS, from a notice in *Chemical and Engineering News*, and from the American Chemical Society's Committee on the Handicapped. Criteria used in selection included:

(1) achieve a balance among three areas of physical impairments: hearing, visual, and motor

(2) include chemical educators interested in teaching chemistry to the physically handicapped, but not necessarily handicapped themselves

(3) choose handicapped participants who were handicapped prior to receiving their degrees in chemistry

(4) include at least one handicapped undergraduate majoring in chemistry

We want to thank Mr. Norman V. Steere, P.E., Laboratory Safety and Design Consultant, for his advice on the content of the Laboratory Safety Section and Mrs. Virginia Stern and Dr. Martha Redden of the Project on the Handicapped in Science at the American Association for the Advancement of Science for their assistance and encouragement throughout this project.

Participants in the Workshop

Many of the participants feel qualified to advise on matters concerning a handicapped student in chemistry and would be happy to offer additional help, if asked. Those noted with an asterisk have so indicated. Participants are listed below according to the discussion area they were involved in at the workshop.

Hearing Impairment

*Dr. B. Edward Cain
Associate Professor
Department of Chemistry
Rochester Institute of Technology
Rochester, NY 14623

*Ms. Catherine L. Gatchell
Research Technician
Department of Medicinal Chemistry
University of Kansas
Lawrence, KS 66045
(deaf)

*Dr. John J. Gavin
Associate Director for Research and Development
Hollister-Stier Laboratories
Spokane, WA 99220
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*Mr. Robert S. Menchel
Employment Opportunities Analyst
National Center on Employment of the Deaf at the National Technical Institute for the Deaf
Rochester Institute of Technology
One Lomb Memorial Drive
Rochester, NY 14623
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*Dr. Edwin J. Parks
Chemist
Chemical and Biodegradation Processes Group
Chemical Stability and Corrosion Division
National Bureau of Standards
Washington, D.C. 20234
(deaf)

*Dr. Nansie S. Sharpless
Assistant Professor
Department of Psychiatry
Albert Einstein College of Medicine
1300 Morris Park Avenue
Bronx, NY 10461
(deaf)

Dr. Joseph J. Lagowski
Editor, Journal of Chemical Education
Professor, Department of Chemistry
University of Texas, Austin

Visual Impairment

Dr. Glenn A. Crosby
Professor
Department of Chemistry
Washington State University

*Mr. Richard V. Hartness
Undergraduate Biochemistry Student
East Carolina University
Greenville, NC 27834
(totally blind)

*Ms. Irene Hecht
Premedical Student
Department of Biology,
Barnard College
Columbia University
New York, NY 10027
(legally blind)

Mr. William Skawinski
Ph.D. Candidate in Chemistry
Macrolab
New Jersey Institute of Technology
(blind)

*Dr. David C. Lunney
Professor
Department of Chemistry
East Carolina University
Greenville, NC 27834

*Mr. H. David Wohlers
Ph.D. Candidate
Department of Chemistry
Kansas State University
Manhattan, KS 66506
(blind)

Ms. Dorothy Tombaugh
Teacher, Author, and Lecturer
971 Richmond Road
Lyndhurst, OH 44124

Orthopedic Impairment

*Mr. Todd A. Blumenkopf
Ph.D. Candidate
Department of Chemistry
University of California
Berkeley, CA 94720
(uses a wheelchair)

*Mr. Ian Brindle
Instructor
Department of Chemistry
Brock University
St. Catharines, Ontario L2S 3A1
Canada

*Dr. Thomas Kucera
Vice President
Apeco Corporation
2400 Lunt Avenue
Elk Grove Village
Illinois 60007
(mobility impaired)

*Dr. Robert Larsen
Analytical Chemist
Argonne National Laboratory
Radiological and Environmental Research Division
Argonne, IL 60439
(walks with crutches and uses a wheelchair)

Mr. Richard Olson
Chemist
Food & Drug Administration
Kansas City, MO
(uses a wheelchair)

*Dr. Anne B. Swanson
Assistant Professor of Chemistry and Chairperson
Department of Physical Sciences
Edgewood College
Madison, WI 53711
(mobility impaired)

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